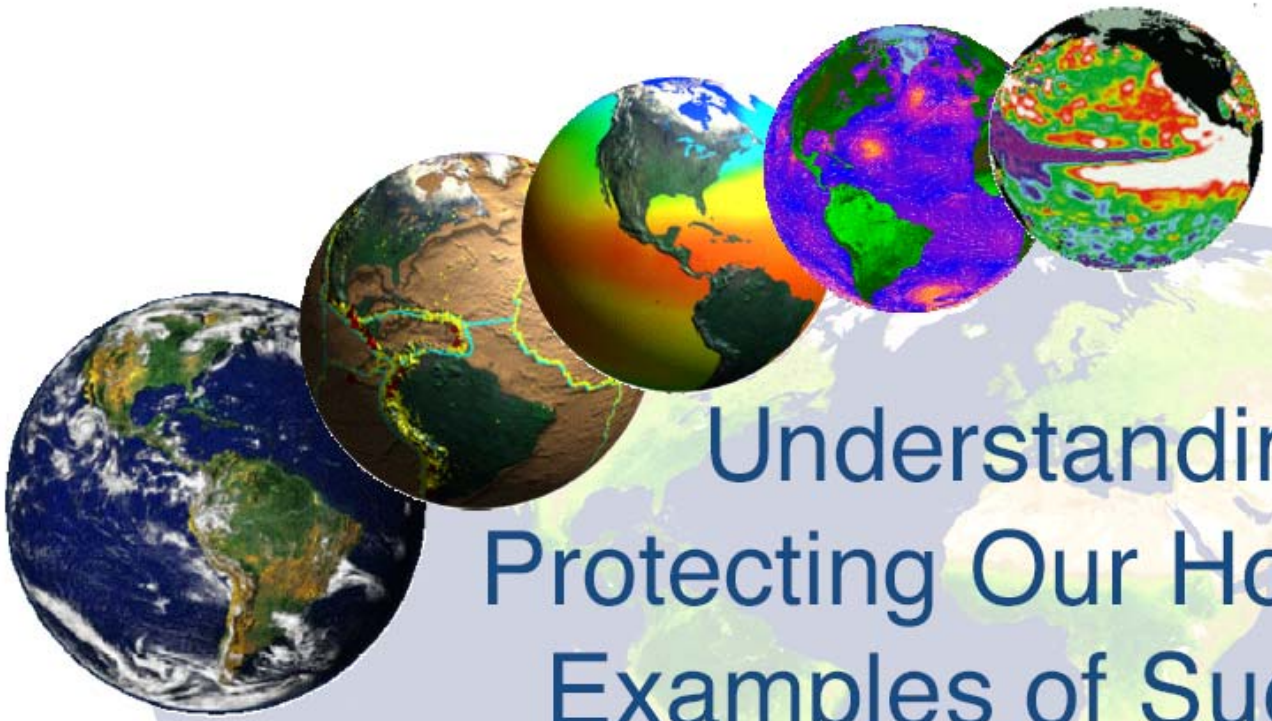
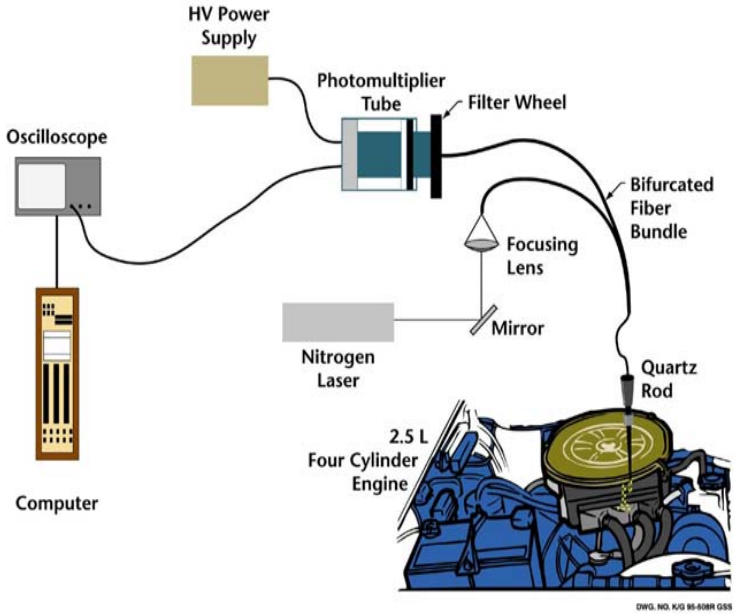


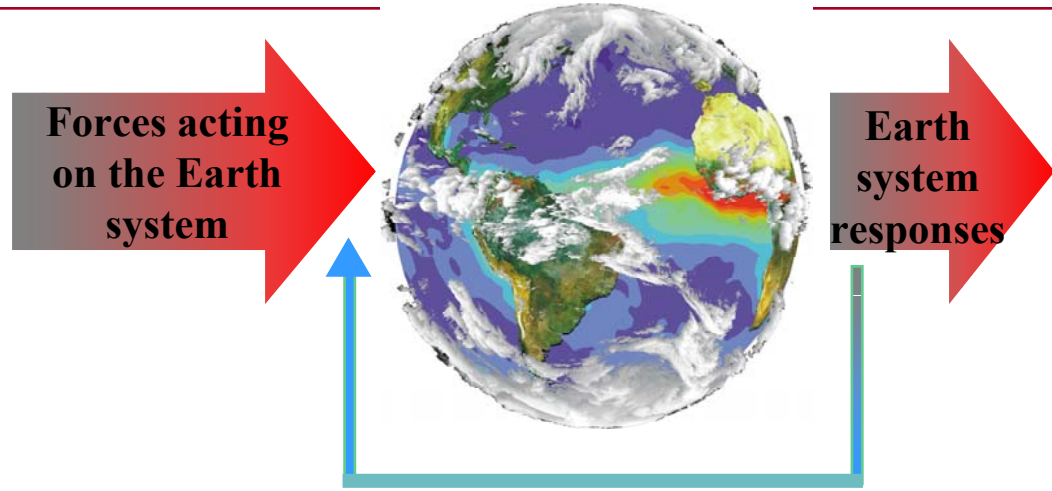
Understanding and Protecting Our Home Planet: Examples of Success and Implications for Life on Earth

NASA's Earth Science Enterprise and Goddard Space Flight Center

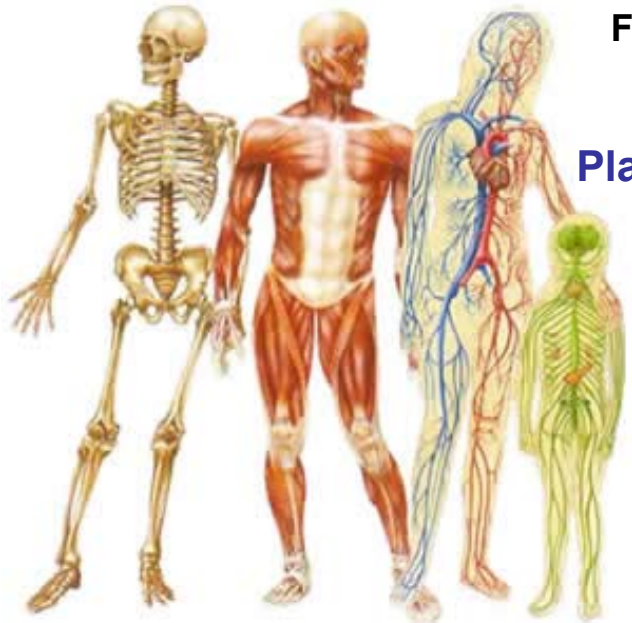
J. Marshall Shepherd, Ph.D

Important Systems For Life





Feedbacks

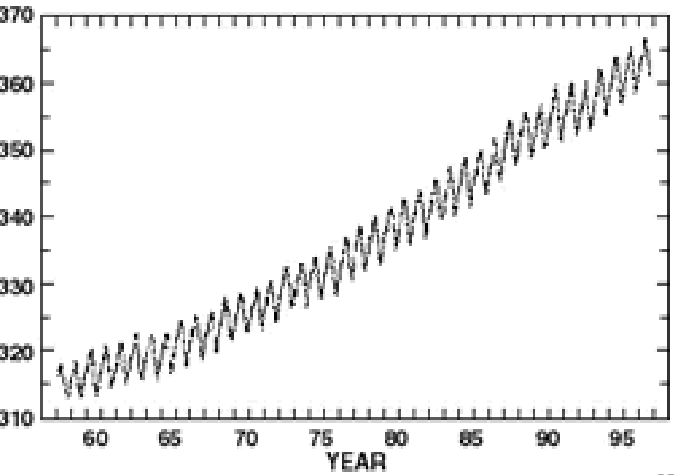


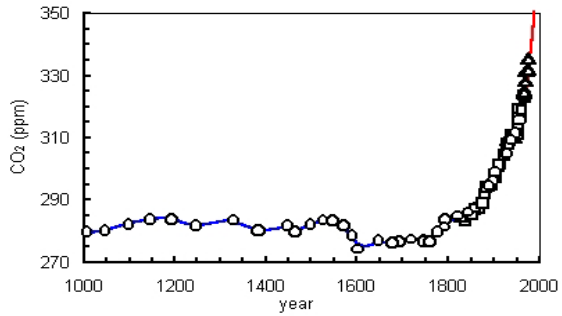
Planet Earth is a Dynamic System


The NASA Vision
To improve life here,
To extend life to there,
To find life beyond.
The NASA Mission
To understand and protect our home planet,
To explore the universe and search for life,
To inspire the next generation of explorers
... as only NASA can.

Earth System Change

Natural processes on human time scales





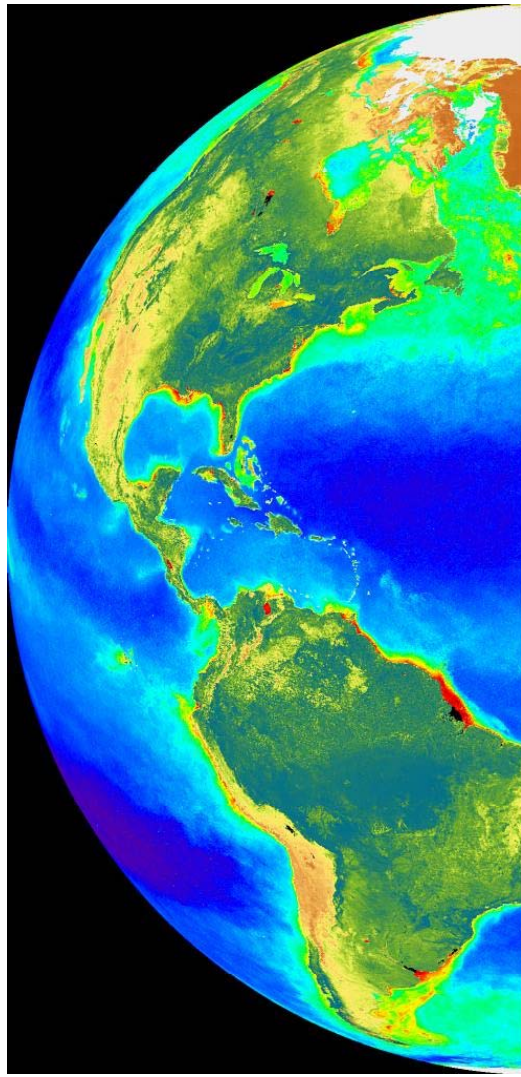
Human activities increasingly affecting natural processes

How is the Earth system changing, and what are the consequences for life on Earth?

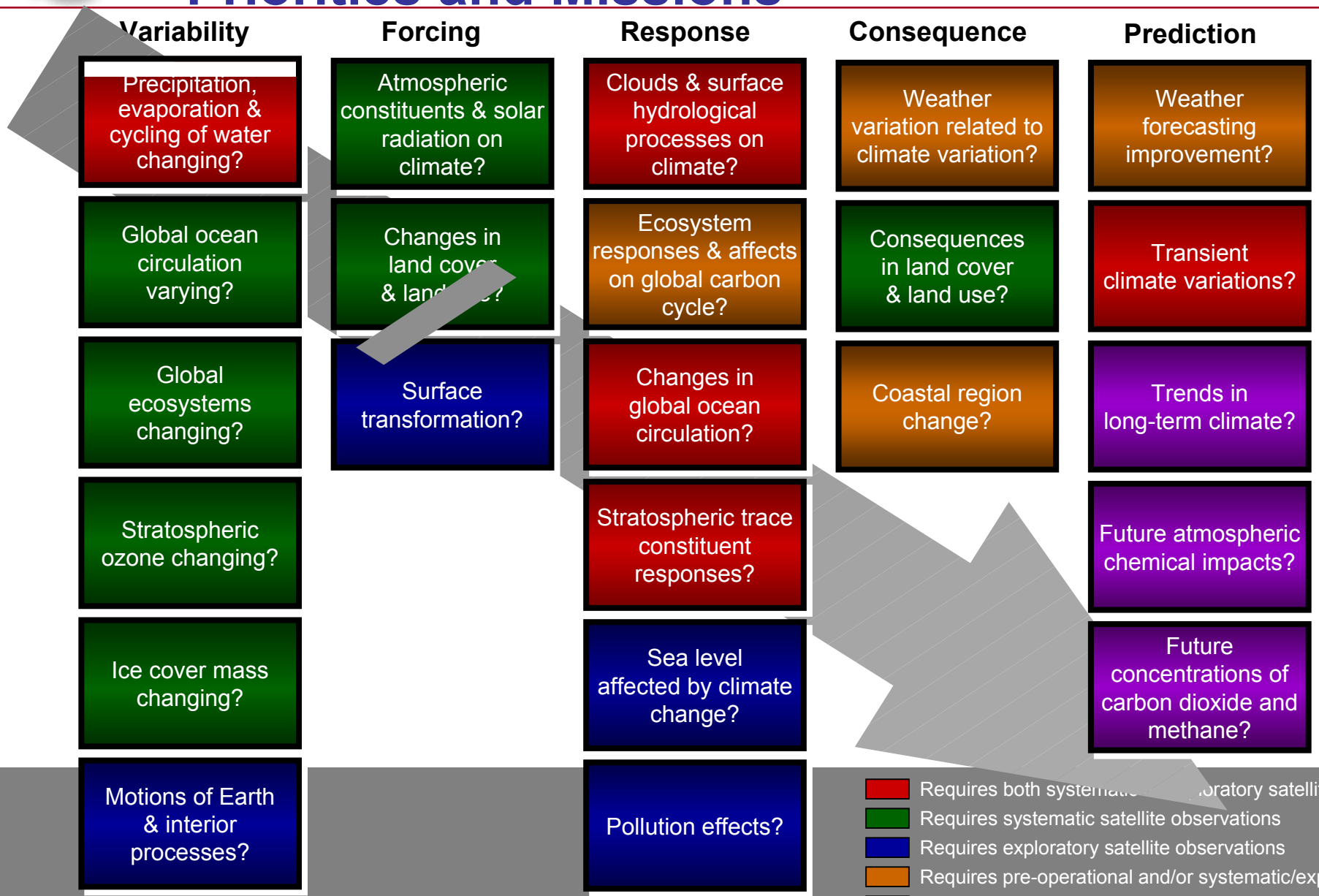
Science Questions

How is the Earth changing and what are the consequences of life on Earth?

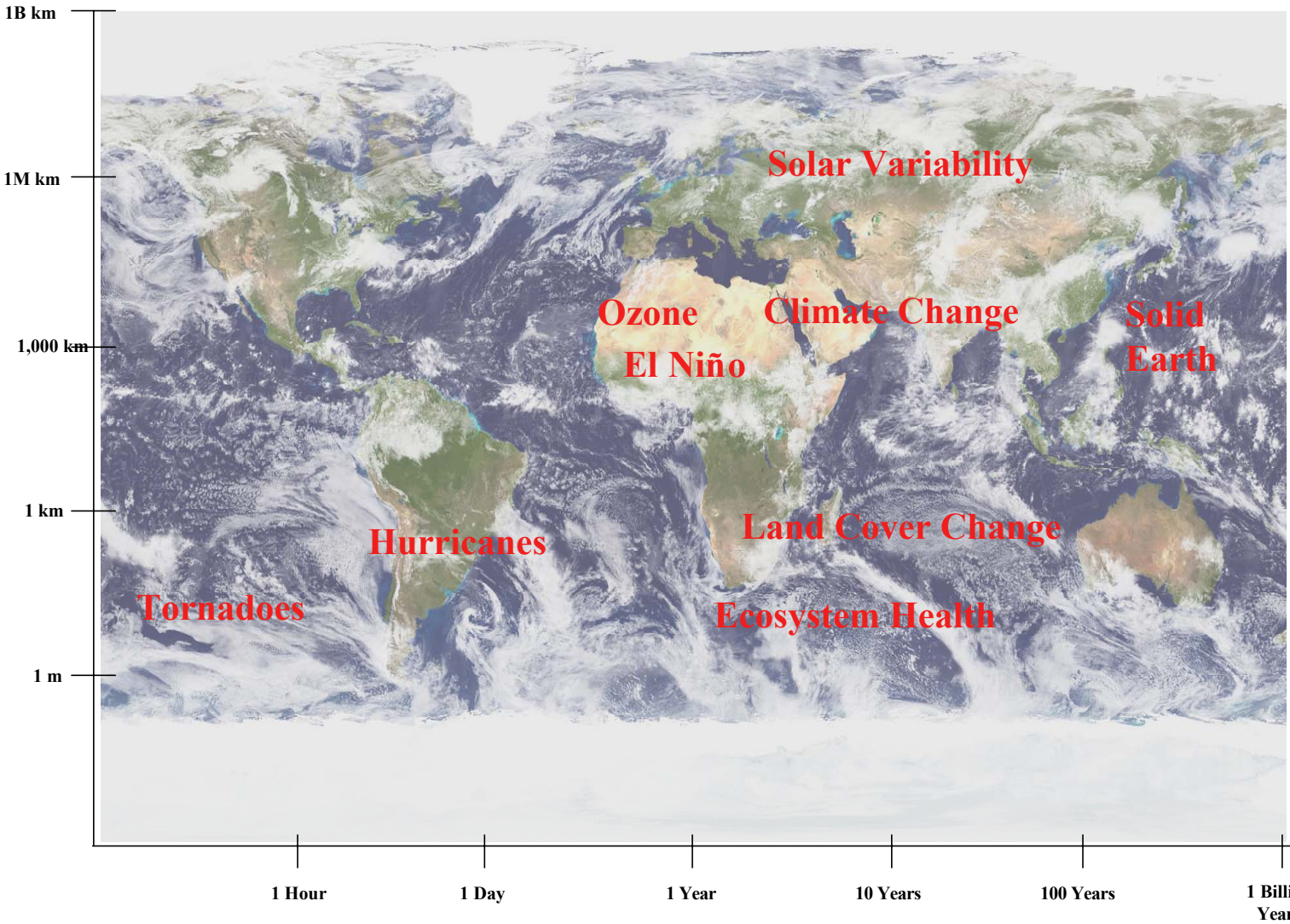
- How is the global Earth system *changing*?
- What are the primary *forcings* of the Earth system?
- How does the Earth system *respond* to natural and human-induced changes?
- What are the *consequences* of changes in the Earth system for human civilization?
- How well can we *predict* future changes in the Earth system?



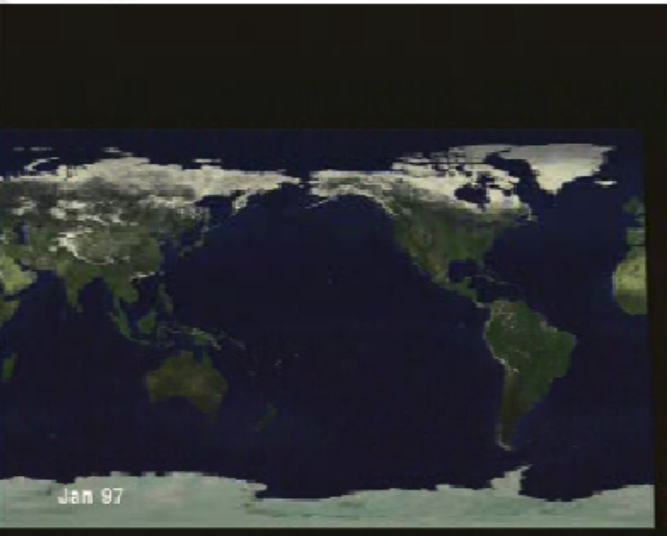
ESE Research Questions Guide Science Priorities and Missions

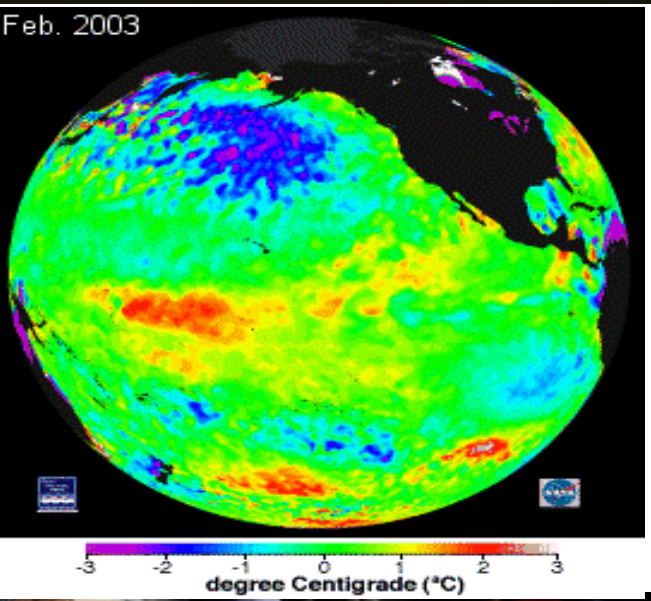


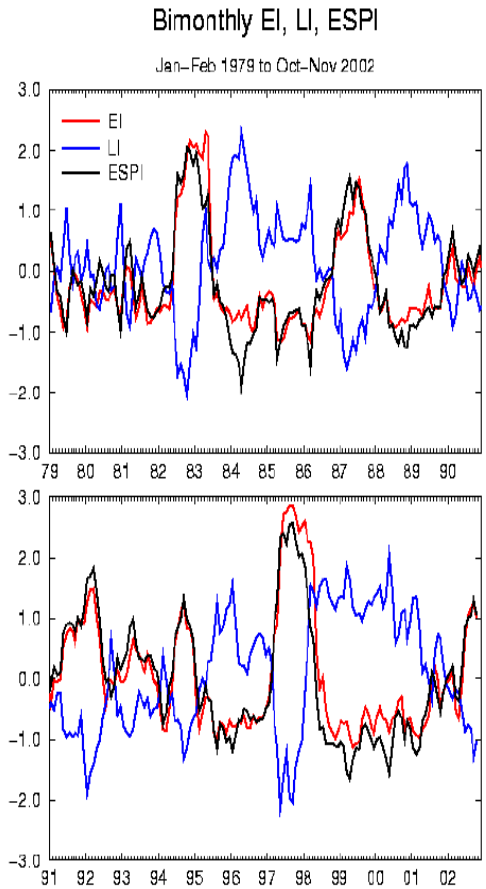
NASA's Earth Science Spans Space & Time

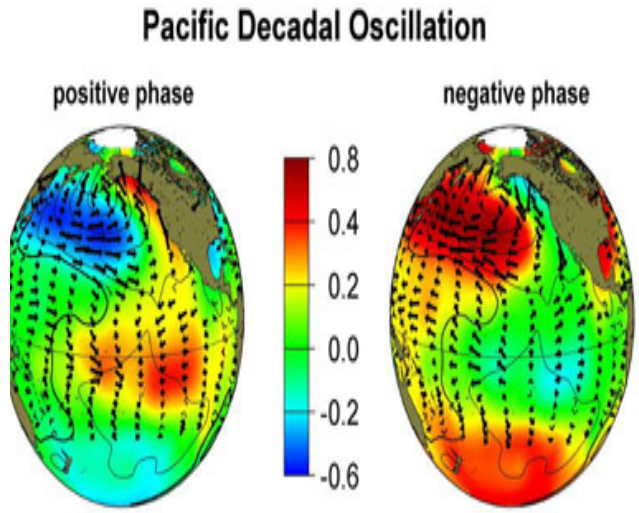


Capturing and documenting global ocean circulation and its role in Earth's weather and climate

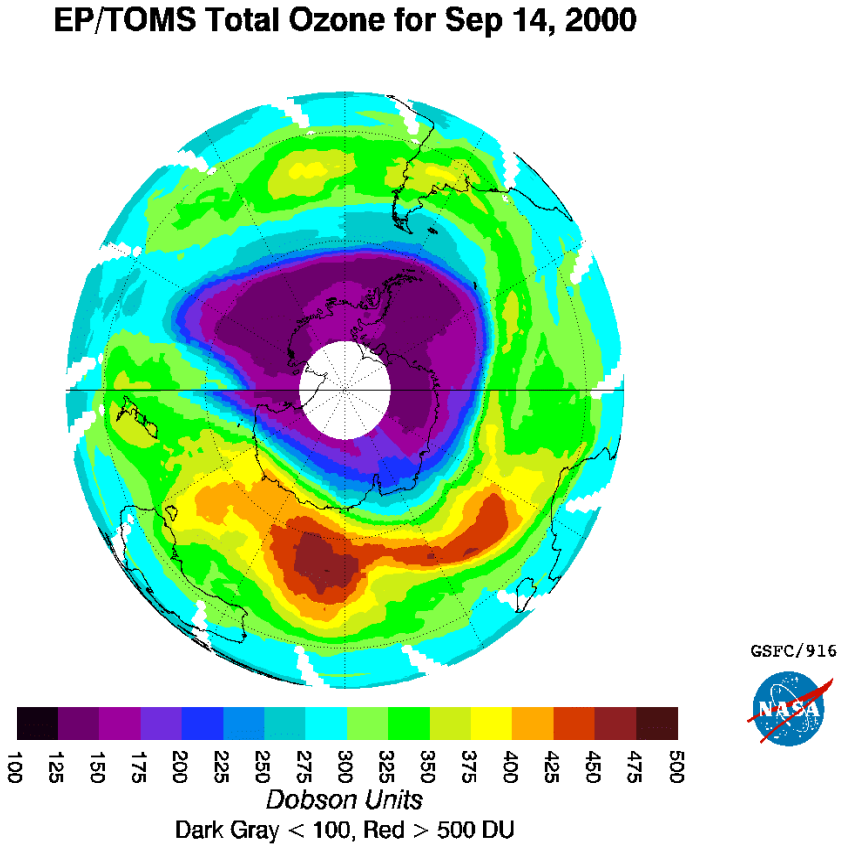




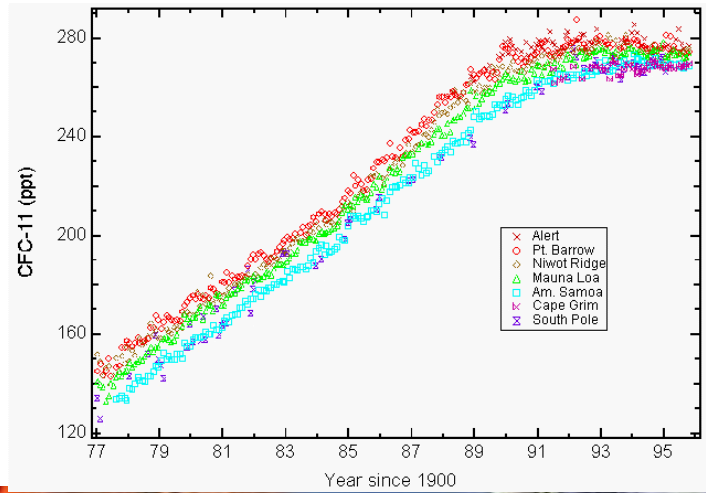




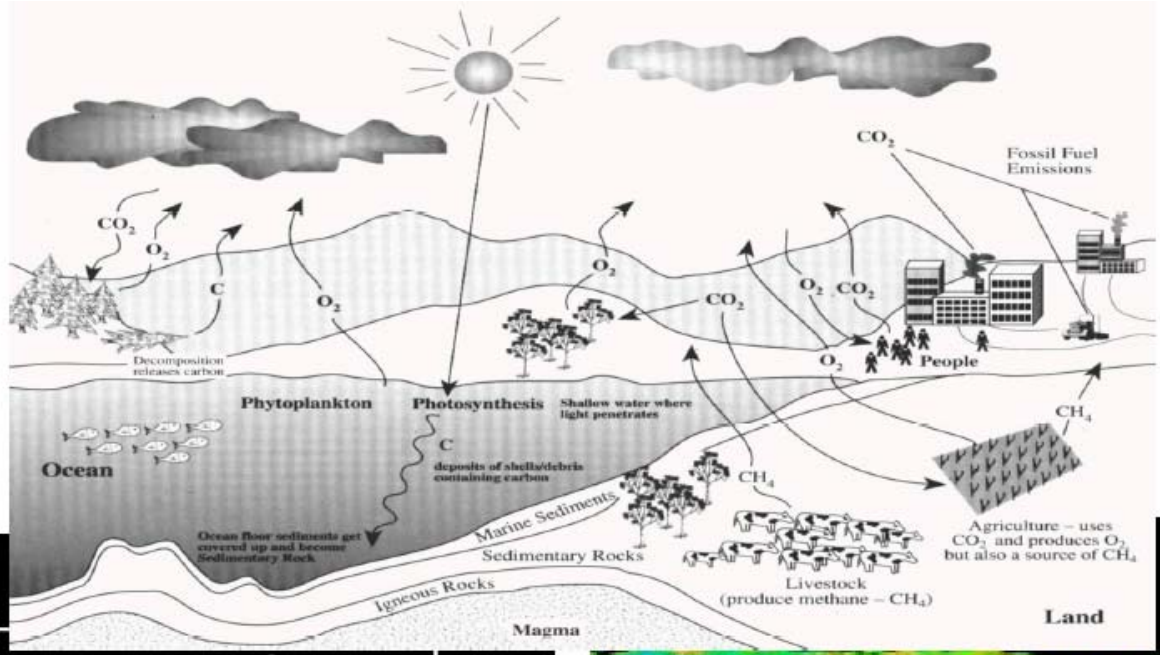
Capturing and documenting dynamics of Earth's Ozone layer and understanding the impacts of its depletion on human existence

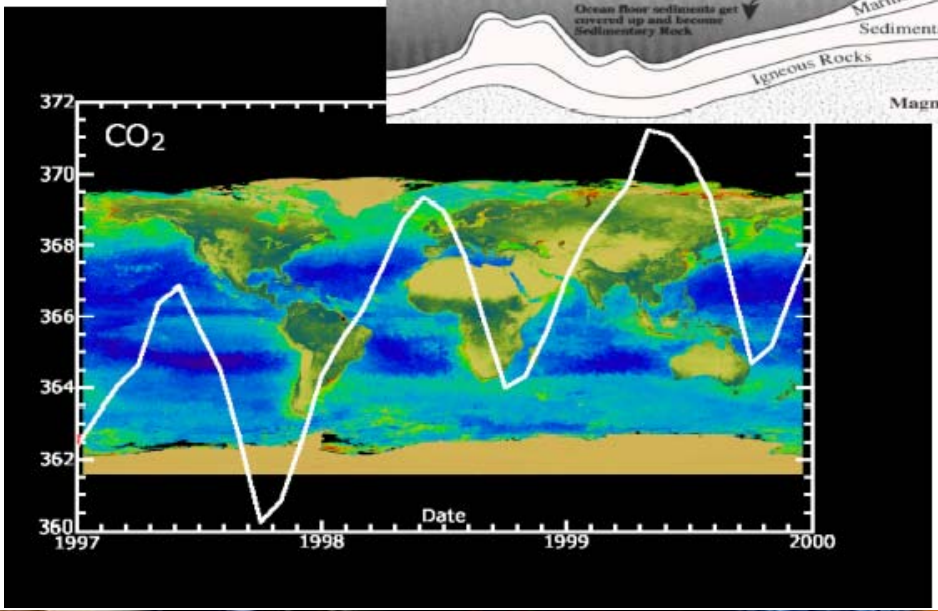


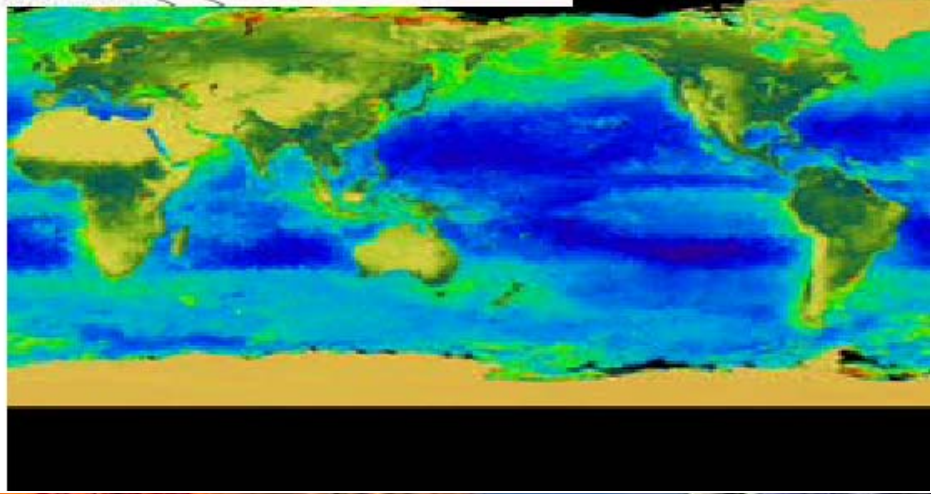
Depletion of ozone over Antarctica as measured by Earth Probe TOMS in September 2000. The purple values are low ozone amounts. The white circle is incomplete data (Image courtesy of NASA TOMS website).



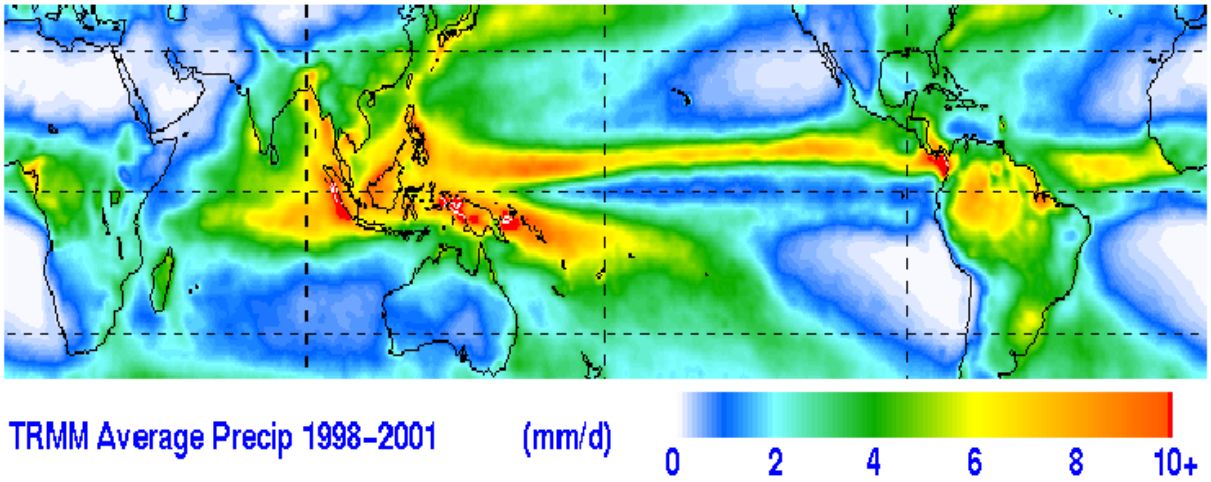
Capturing the seasonal dynamics of land vegetation and ocean phytoplankton, and their capacity to cycle carbon through the Earth system and in food and fiber production





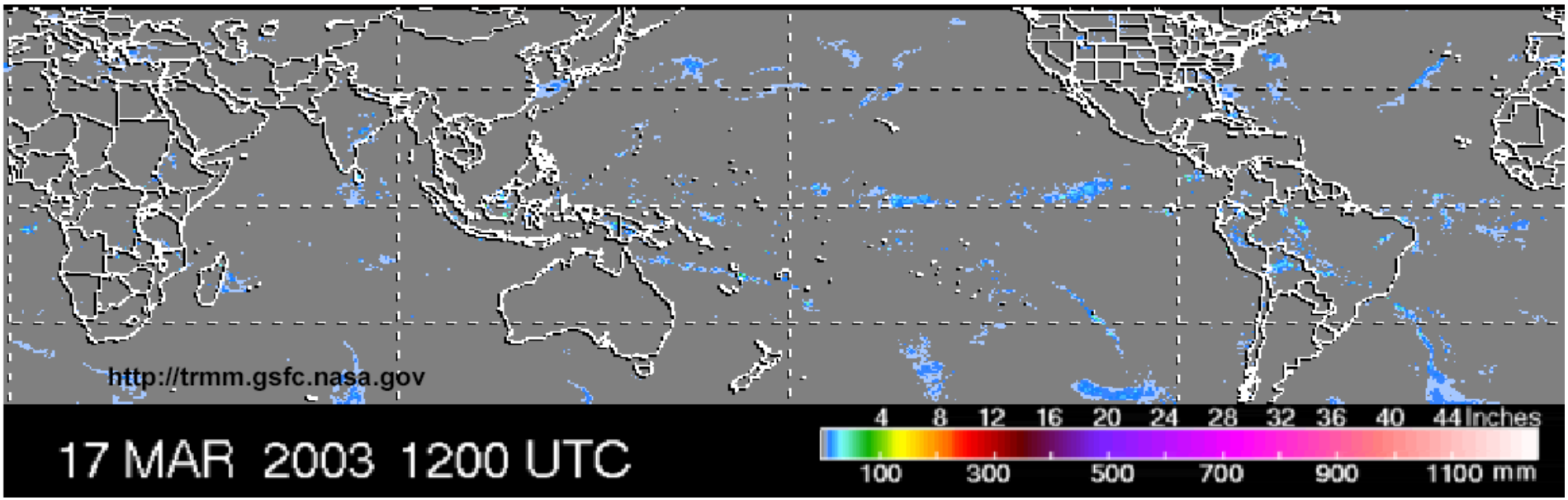


Understanding the distribution/variation in tropical rainfall

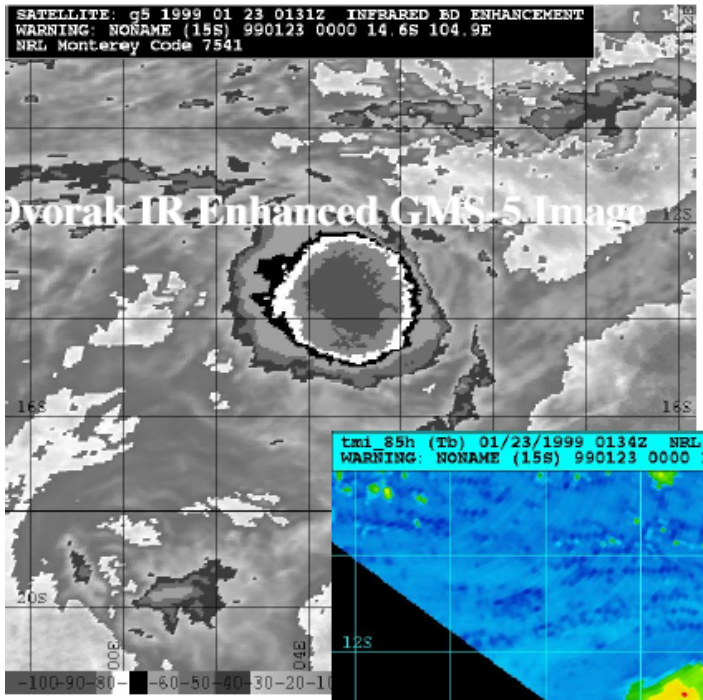


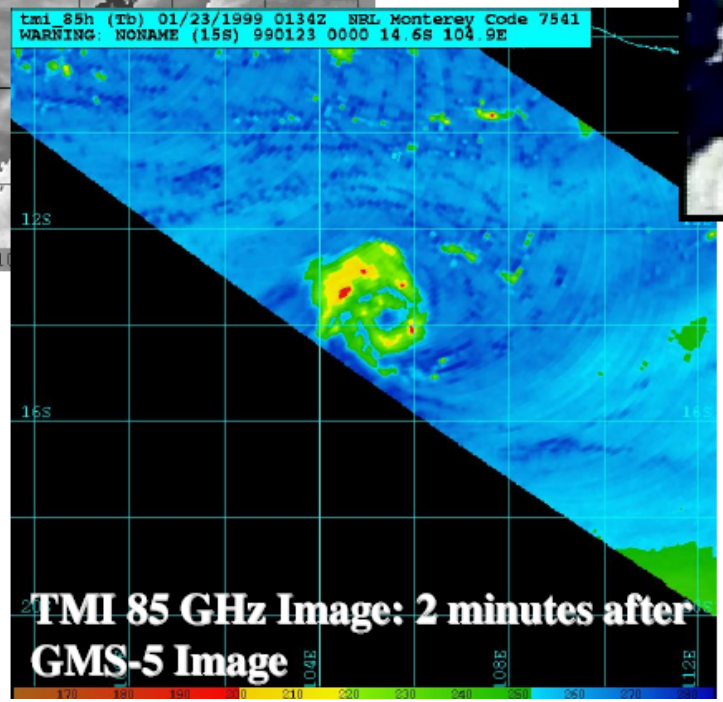
Improved Ocean Rainfall Estimation due to algorithm improvement from pre-TRMM era

Uncertainties in Tropical Rainfall Estimates Reduced from ~50% to ~25% using TRMM



Mapping the 3-D structure of storms and hurricanes, and and their impacts on human safety, property, and infrastructure

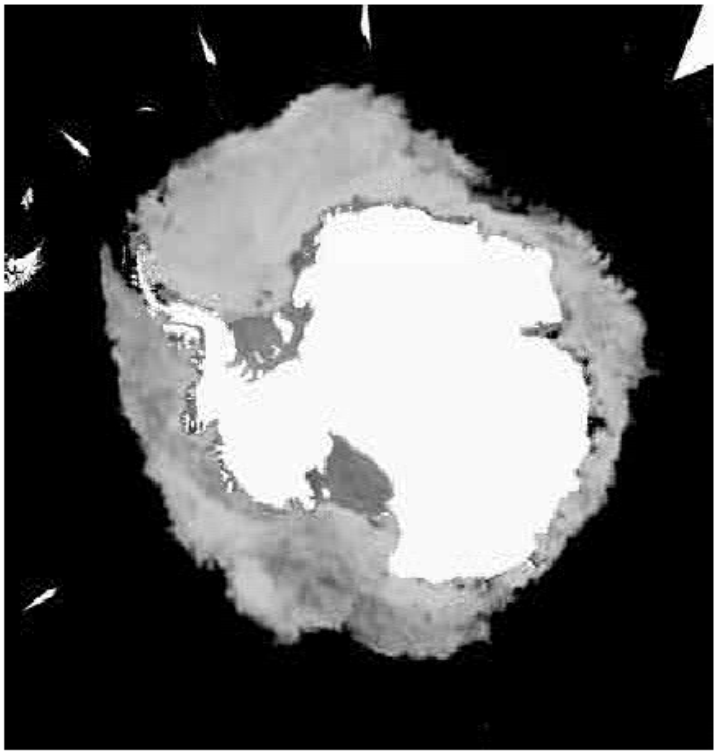




TRMM Active/Passive Microwave Sensors are Better Than Conventional VIS/IR Sensors at Reducing Tropical Storm Fix Error for NHC and DoD

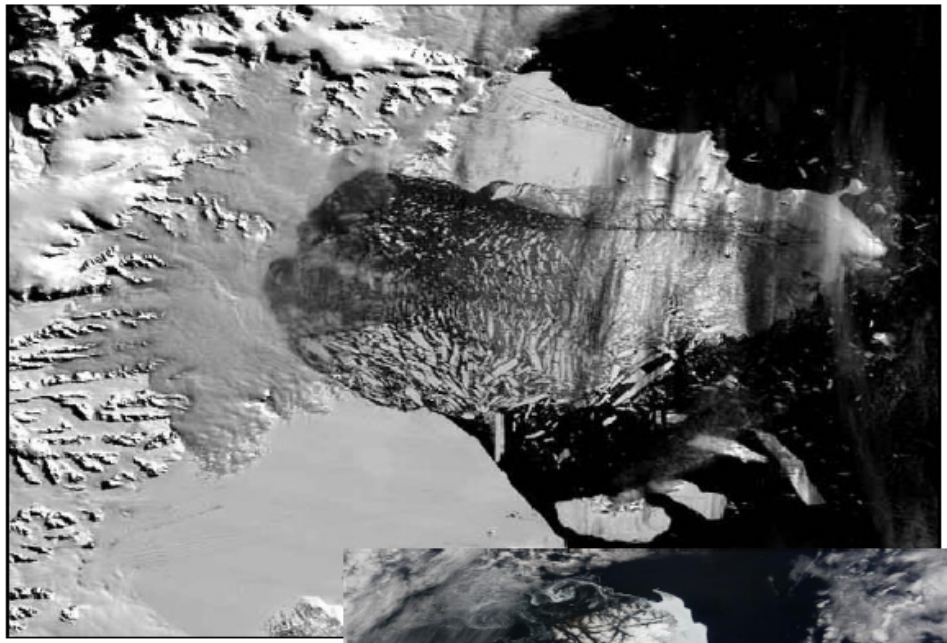
Mapping Greenland and Antarctica in 3 Dimensions with Unprecedented accuracy to understand their role in Earth's weather, climate and sea level change

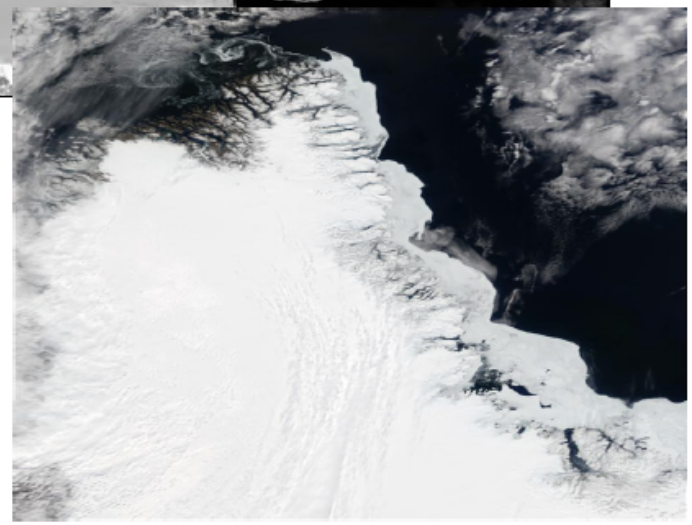
New Map of Antarctica: A New Look at the Motion of Old Ice



Variation of Sea Ice Concentration around the South Pole Jul-Dec 2002 (Aqua-AMSR-E)

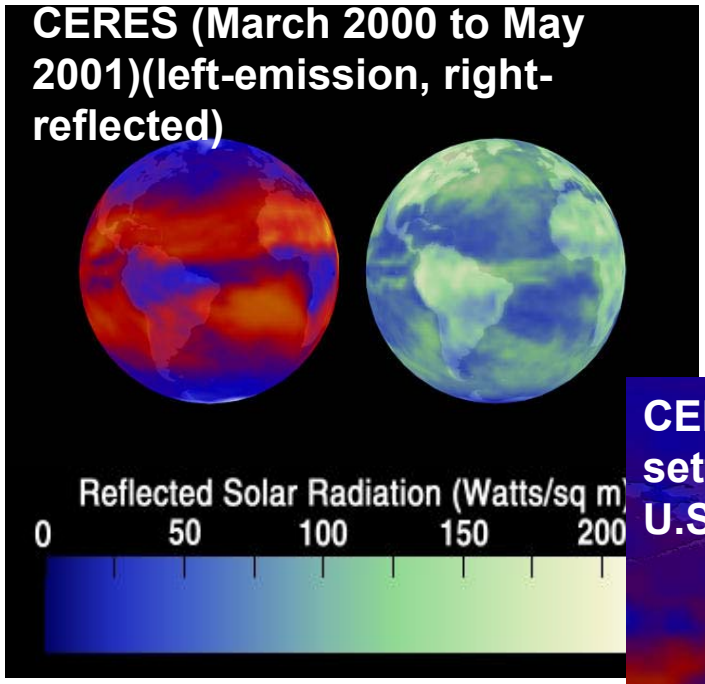
2002 Larsen B Ice Shelf Break Up (Terra MODIS)

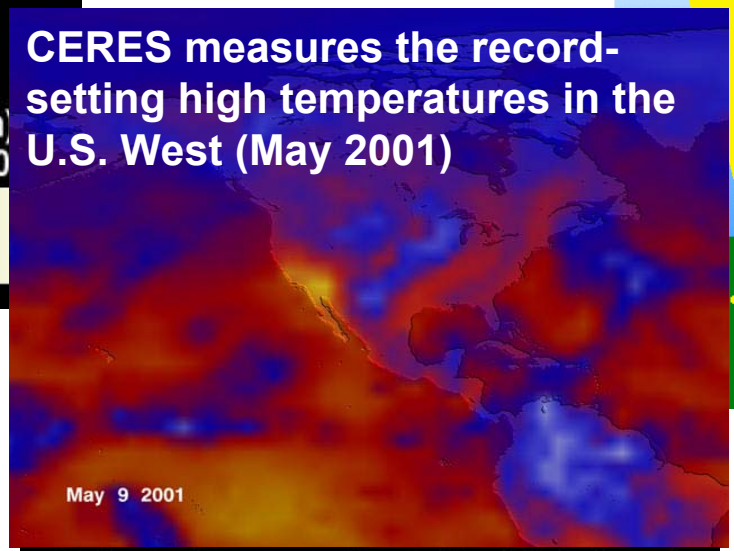


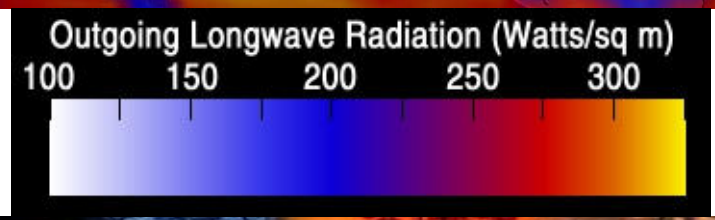


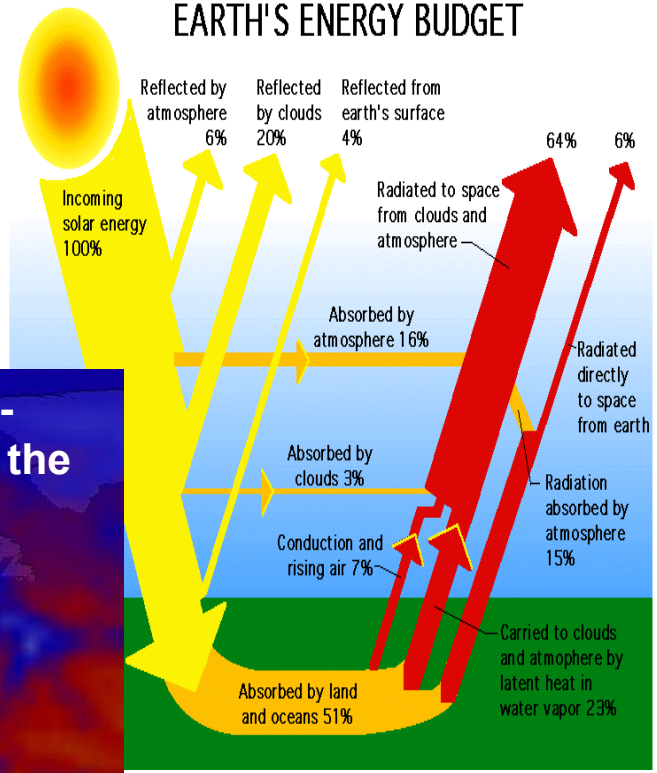
Melting in Greenland (MODIS)

Measuring the Earth's Radiation budget and its variations with unprecedented accuracy to assess its impacts on Earth's climate and weather

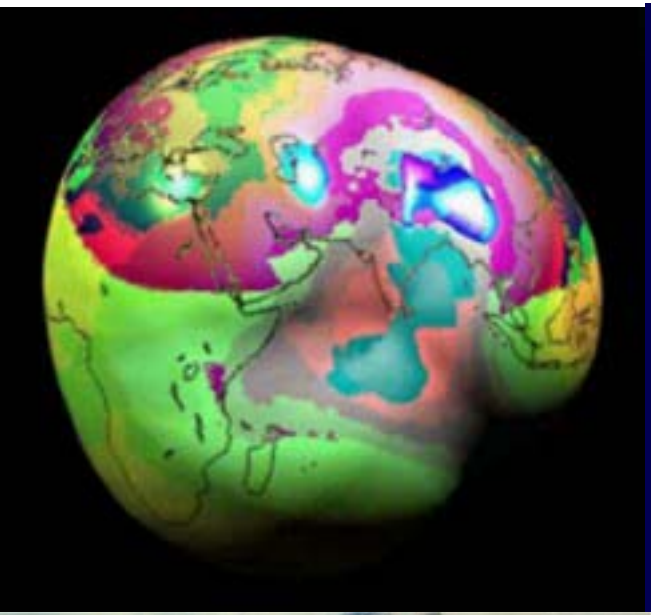


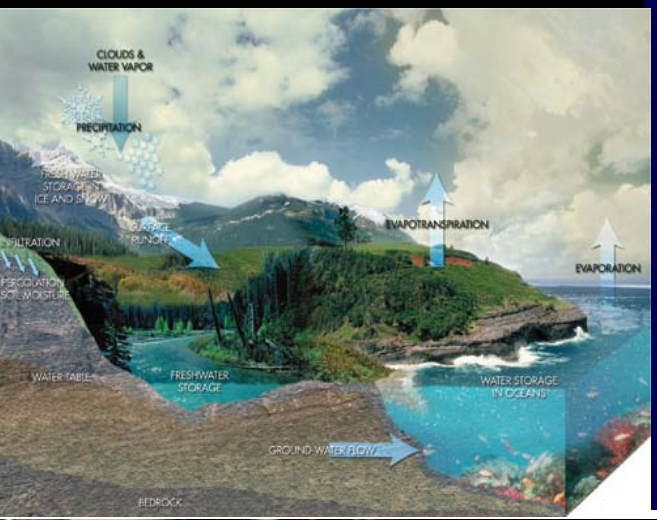


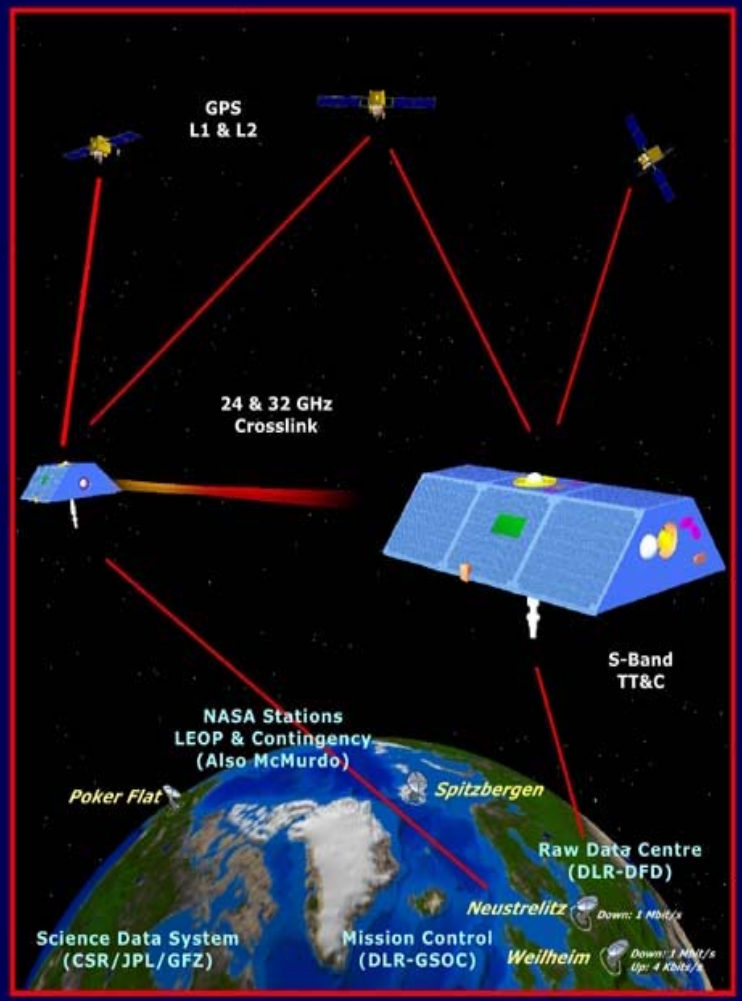




Mapping Earth's gravity field and its variations over time with unprecedented accuracy to assess its impacts on ocean circulation and Earth's climate







GRACE Mission

Science Goals

High resolution, mean & time variable gravity field mapping for Earth System Science applications.

Mission Systems

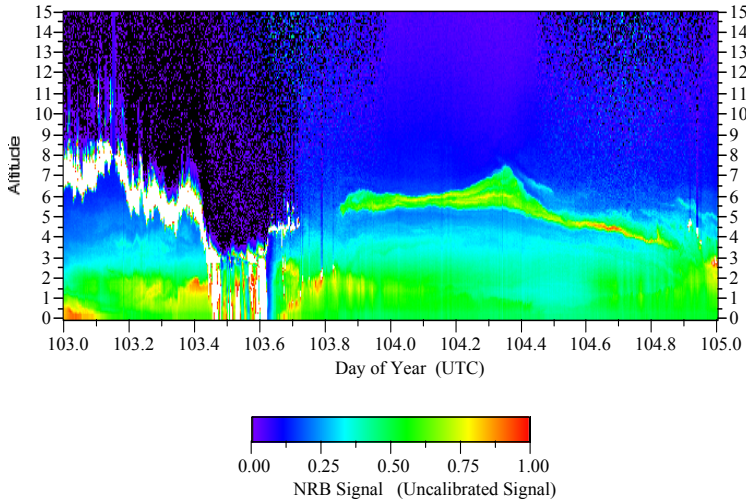
Instruments
- •KBR (JPL/SSL)
- •ACC (ONERA)
- •SCA (DTU)
- •GPS (JPL)

Satellite (JPL/DSS)
Launcher (DLR/Eurockot)
Operations (DLR/GSOC)
Science (CSR/JPL/GFZ)

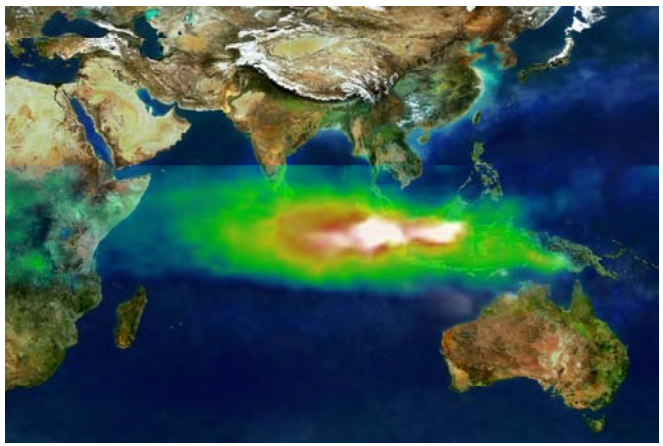
Orbit

Launch: March 2002
Altitude: 485 km
Inclination : 89 deg
Eccentricity: ~0.001
Lifetime: 5 years
Non-Repeat Ground Track
Earth Pointed, 3-Axis Stable

Mapping the distribution of aerosols and clouds and assessing their roles in Earth's climate and energy budget

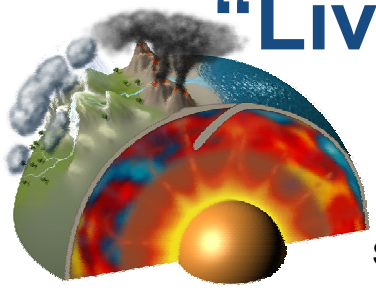


NASA's TOMS Satellite Tracked Pollution Plumes Around the World



Images of Tropospheric ozone tracked by NASA's TOMS satellite clearly demonstrate that air pollution is more than a local problem. Pollution from both biomass burning and industrial activity can travel great distances and affect regions far from the sources.

"Living on a Restless Earth"



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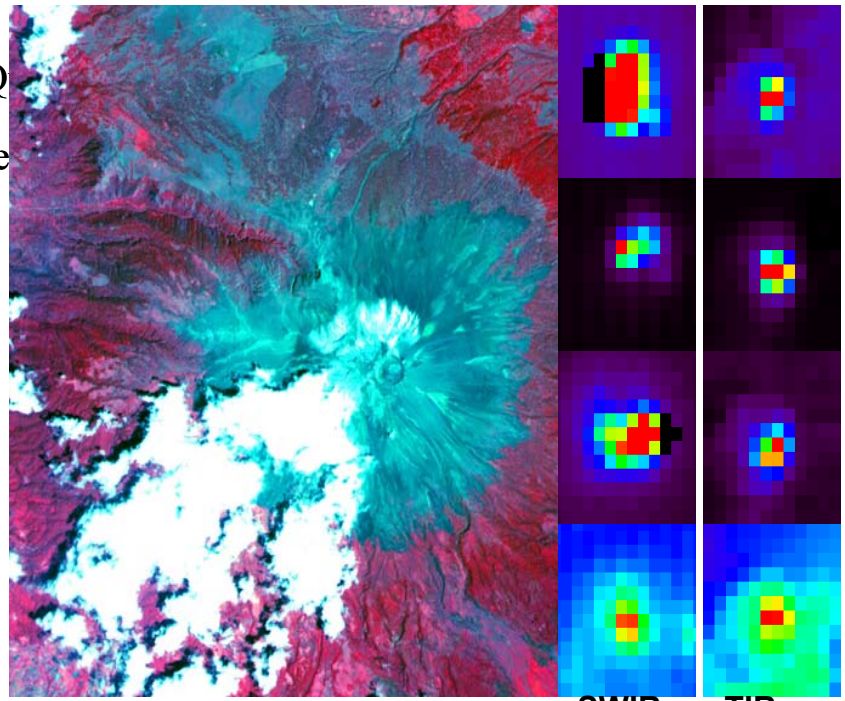
Popocatepetl Volcano, Mexico
Summit Crater in 2000-2001--Terra-ASTER



SWIR TIR

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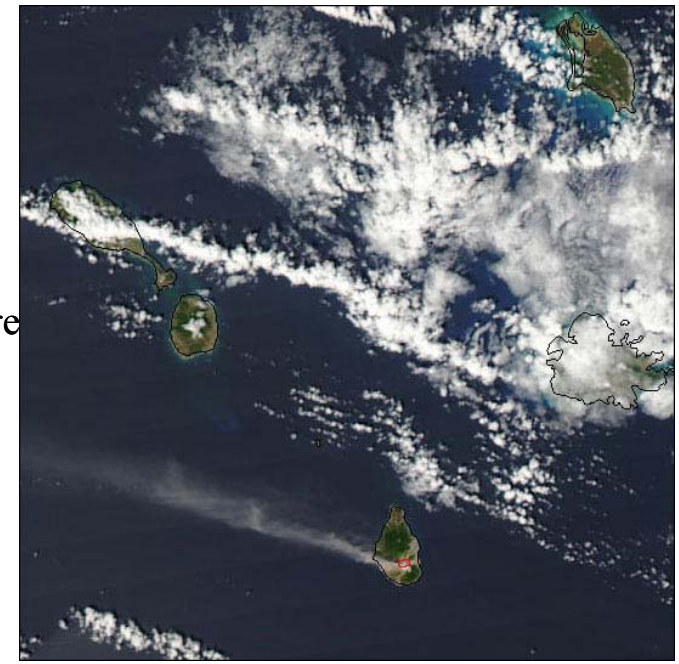
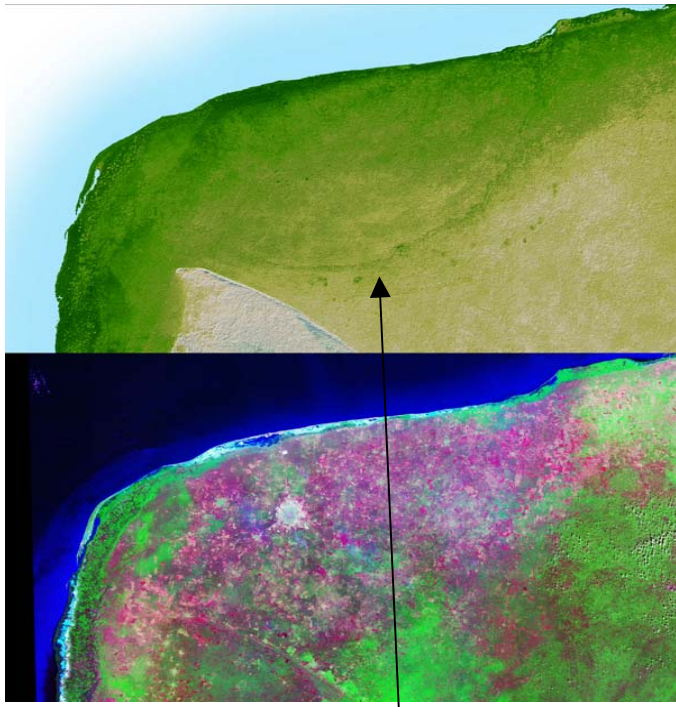
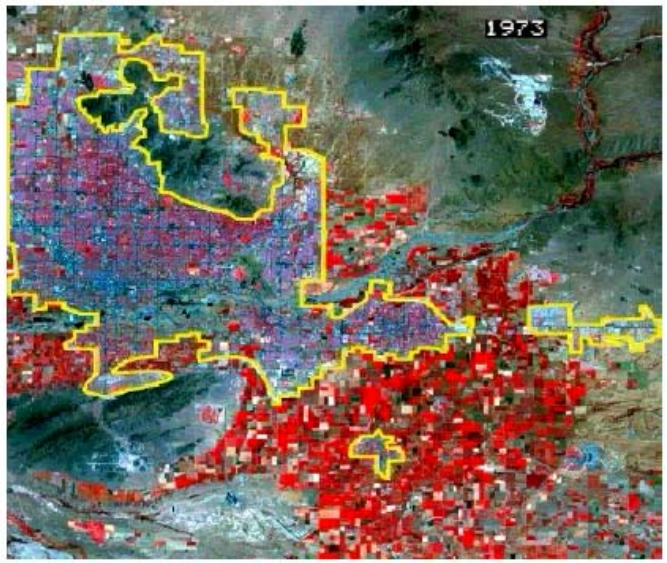


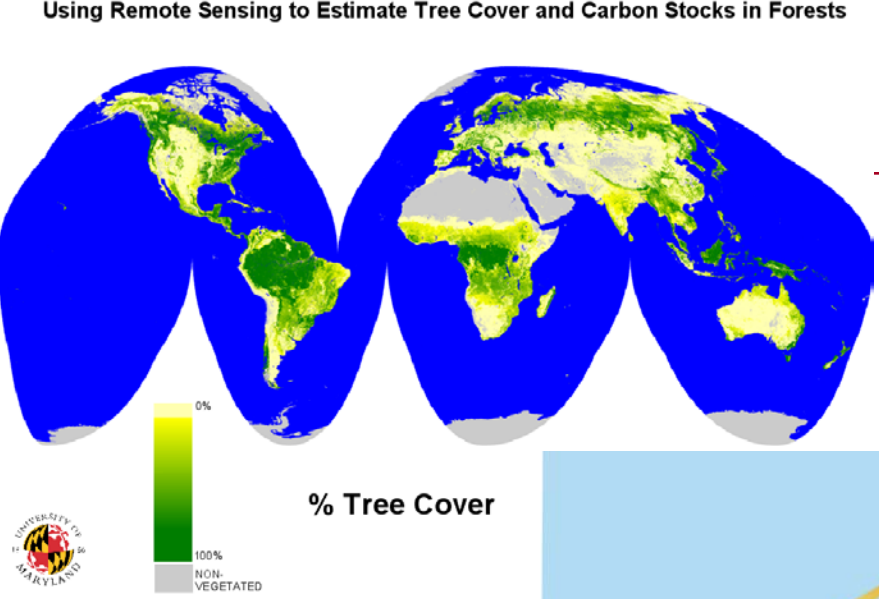
Feb 22, 2003 Eruption at Soufriere Hiills, Montserrat (MODIS-Aqua)

Mapping the Earth's surface in 3D with unprecedented accuracy and resolution and using this knowledge to improve several national applications areas



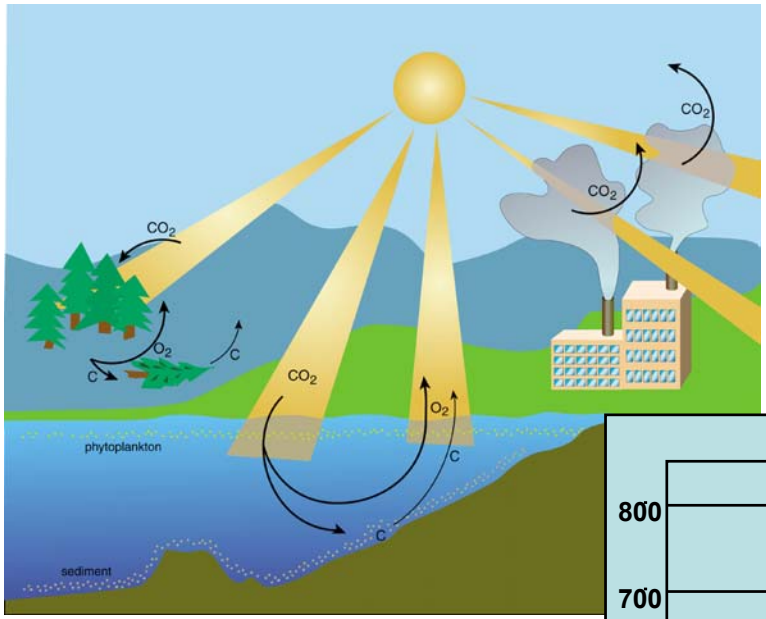


NASA's Approach to Earth System Science



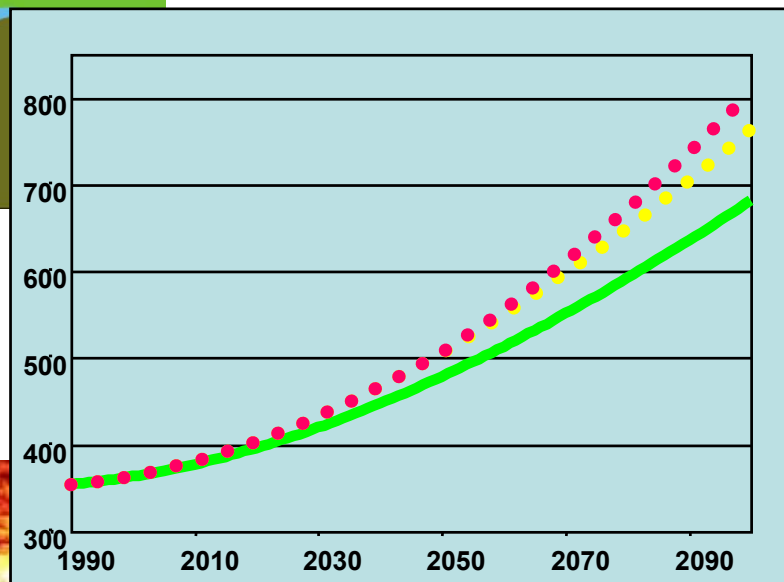
Characterize

Understand



Possible Effects of Ecological Processes on Future Carbon Dioxide Levels?

Predict

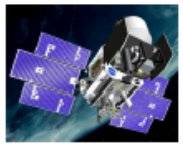


Next Generation Missions

In Formulation

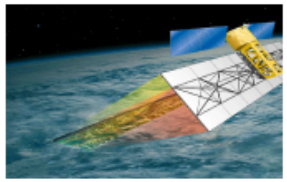
Candidate Future Missions

Next generation systematic measurement missions to extend / enhance the record of science-quality global change data.



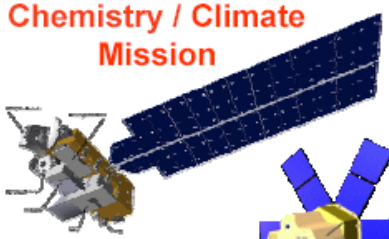
Cryosphere Monitoring Mission

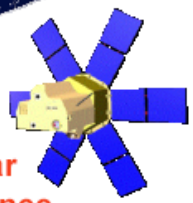
Synthetic Aperture Radar



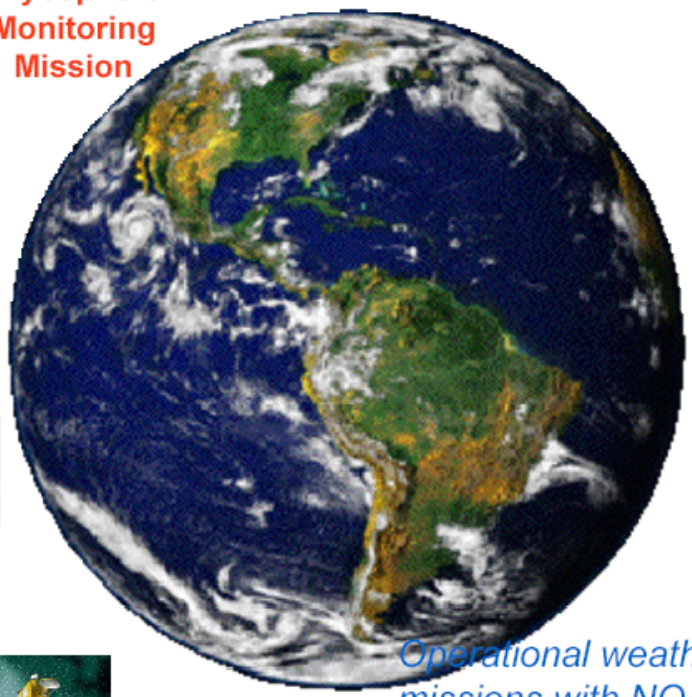
Exploratory missions to probe key Earth system processes globally for the first time

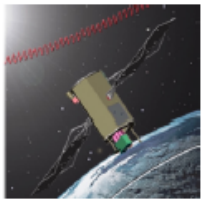
Chemistry / Climate Mission





Solar Irradiance Measurement





Orbiting Carbon Observatory

AQUARIUS

Global Precipitation Measurement

Total Column Ozone

Future exploratory measurements:

- Soil moisture
- Advanced gravity
- Ocean carbon
- Cold climate processes
- Vegetation recovery
- Deep ocean

Operational weather services missions with NOAA/DoD

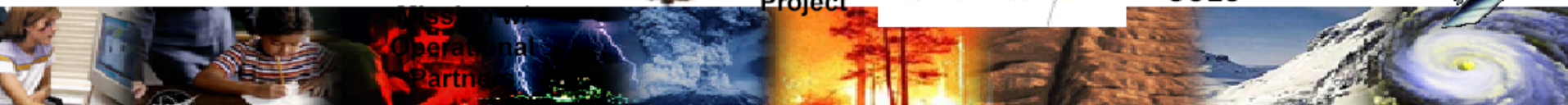
Landsat Data Continuity via Commercial Partnership

Ocean Surface Topography

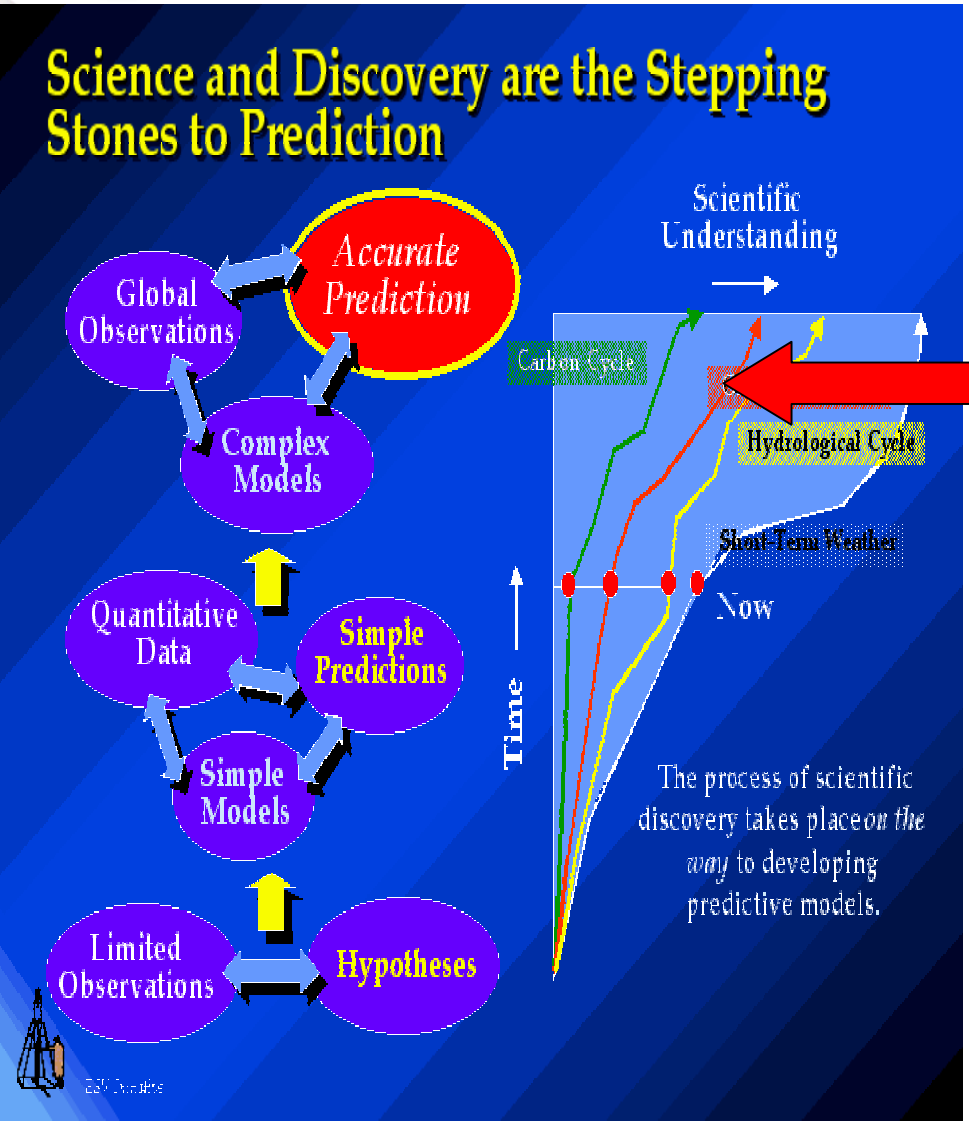
NPOESS Preparatory Project

NOAA/Advanced GOES

NPOESS

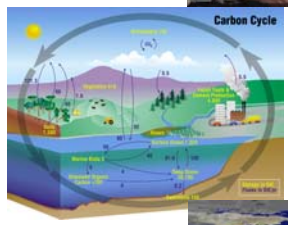


Research Focus Areas

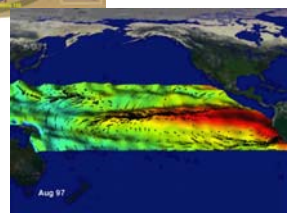


- Water & Energy Cycle

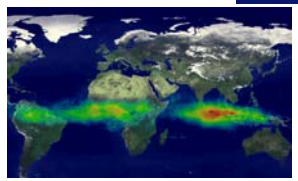
- Carbon Cycle



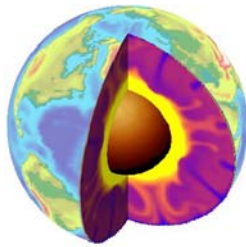
- Weather



- Climate

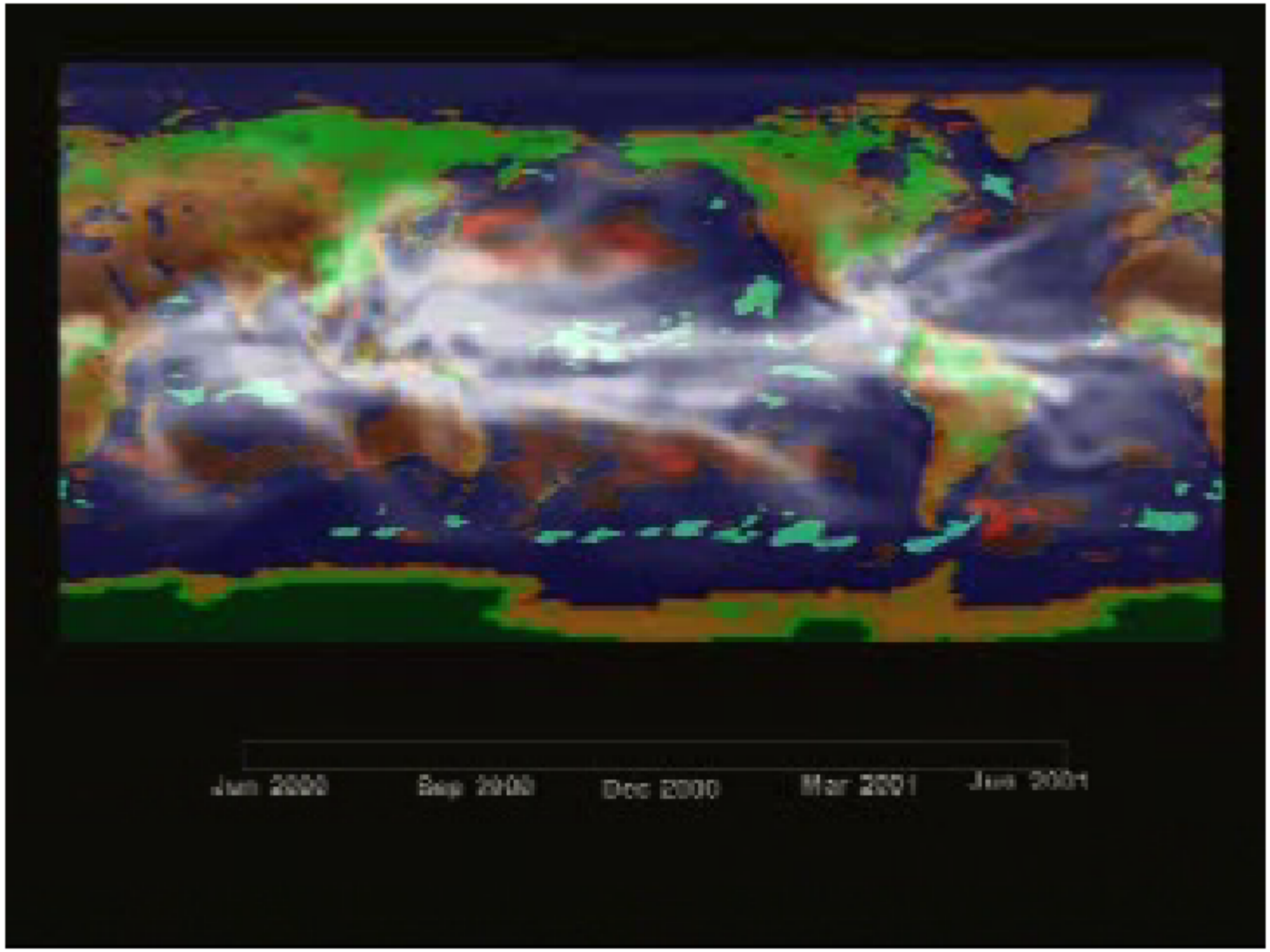


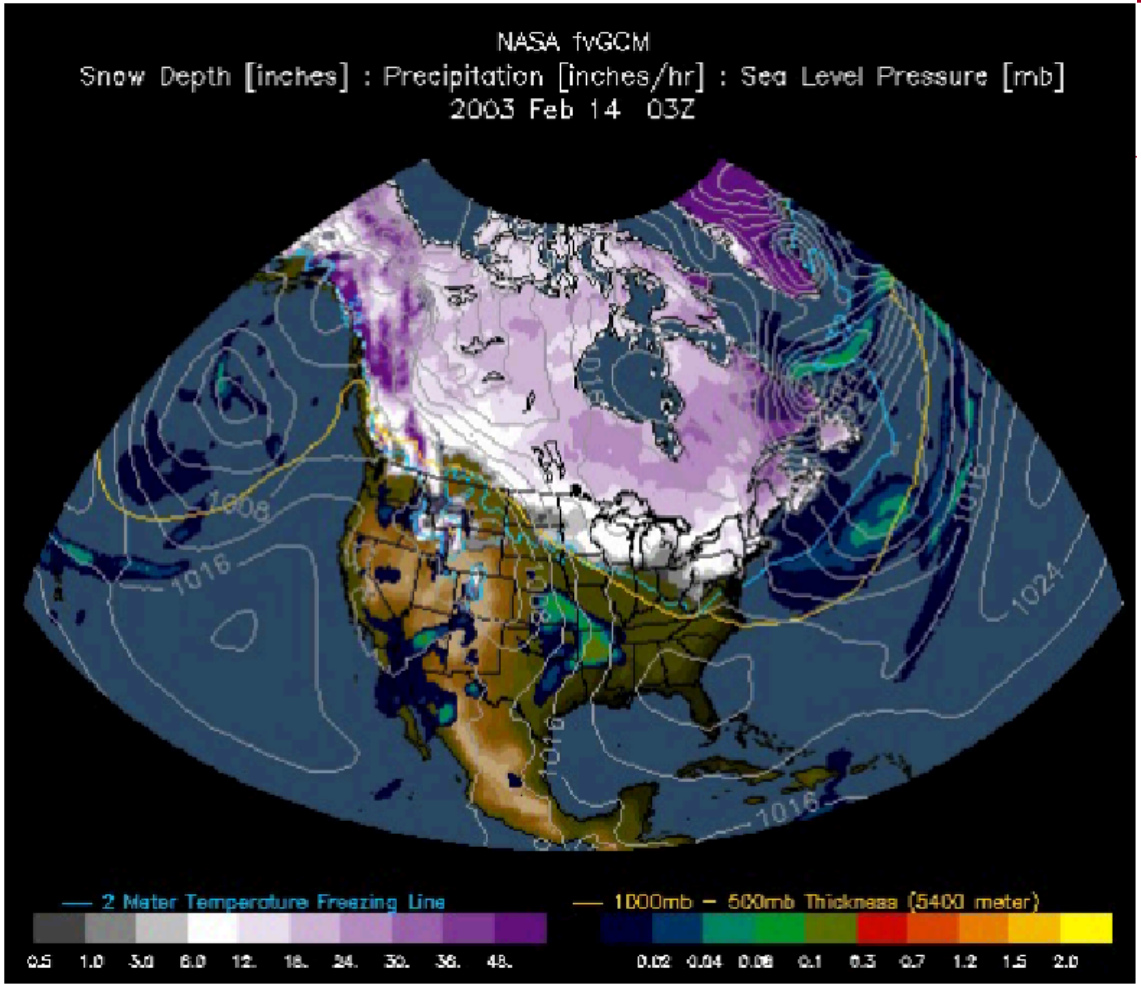
- Atmospheric Composition



- Solid Earth & Natural Hazards

Computational Models Are Key Tools for Understanding & Prediction





Model: NASA/GSFC Data Assimilation Office fvGCM

PI: Bob Atlas and Shian-Jiann Lin

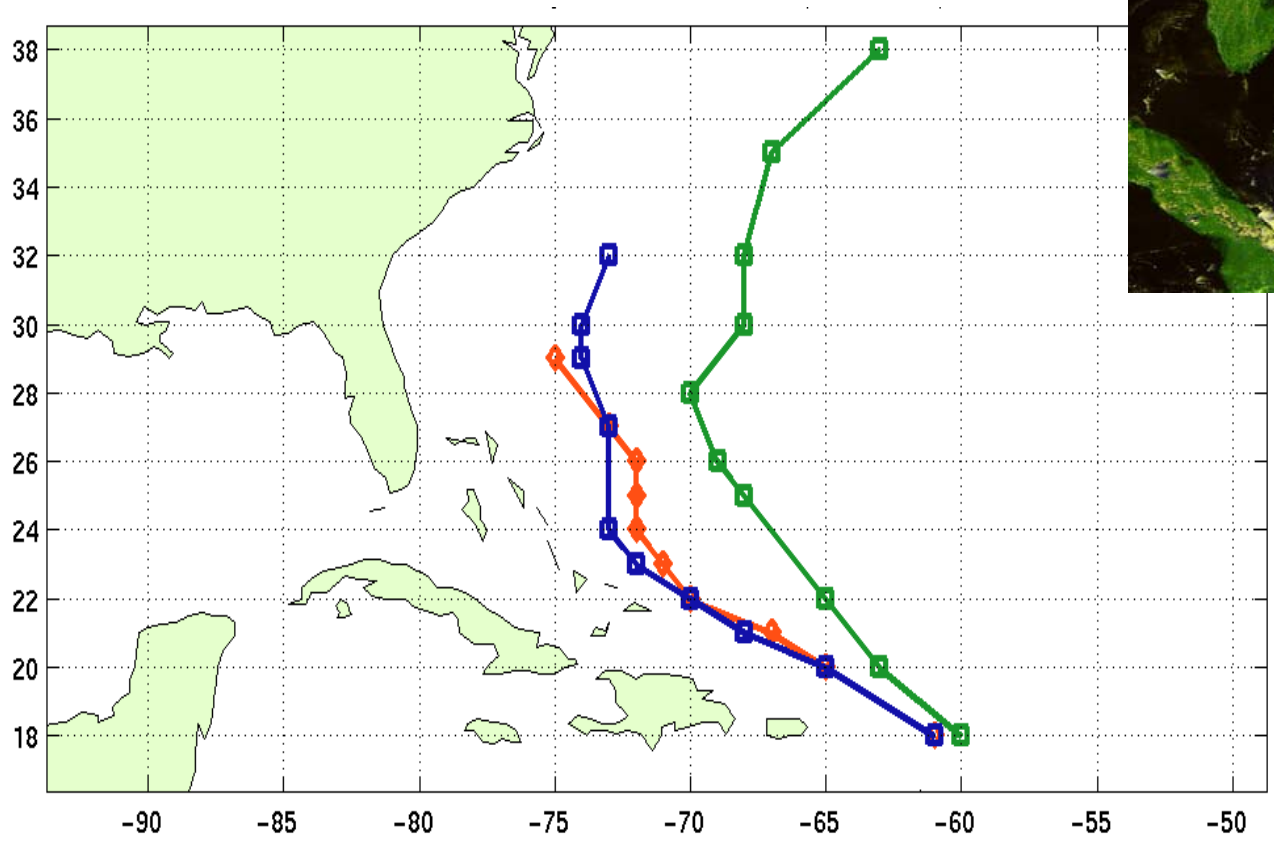
Washington - Baltimore "Snowstorm of the Millenium"

Textbook example of the synergy observations, modeling, assimilation, and improved forecast capibility

1. NOAA/NCEP data initialized the model
2. NOAA/NCEP sent the analysis to NASA
3. NASA performs model run, QuikSCAT data assimilated, sent back to NCEP

Improving Storm Prediction

5-day forecast from 08/20/98 12:00



Red: best track (NOAA HRD)

Green: forecast from analysis without precipitation data

Blue: forecast from analysis with precipitation data

Solutions: Science to Decision Support

Science Models

- Oceans
- Ice
- Land
- Coupled
- Atmosphere

Data

Monitoring & Measurements

- Satellite
- *Airborne*
- *in situ*

Predictions

High Performance Computing, Communication, & Visualization

Standards & Interoperability

Observations

Decision Support Tools

- Assessments
- Decision Support Systems

Value & benefits to citizens and society

Policy Decisions

Management Decisions

Inputs *Outputs* *Outcomes* *Impacts*